ON-LOAD VOLTAGE AUTOMATIC ADJUSTMENT DEVICE FOR INSULATED PLACES

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Abstract: This paper refers to new types of three-phase power transformers, which have the possibility of on-load secondary voltage automatic adjustment, using independent means on each phase, to keep its value among prescribed limits when secondary voltage varies among large limits because of operating conditions. These kinds of transformers are especially meant to power supply of isolated places. In accordance with proposed solution, the three-phase power transformer construction and their accessories are made with nowadays means and well-known technologies. The nowadays operating transformers could be adapted to secondary voltage automatic adjustment operating with the aim to keep its value among admissible limits. Experimental results will lead to some improvements and finally, the new solution should be introduced into real operating conditions. The final conclusions highlight that proposed solution is a good choice to keep voltage level from power transformers within admissible limits.

1. Introduction

The nowadays well-known and used on-load tap-changers of voltage power transformers have limiting resistances for a fast drive of diverter switch (Jansen type) or limiting reactance's and slowly drive of diverter switch. Their principle relies on changing one tap to another adjacent one with momentary short-circuiting of these two taps winding, so it varies the winding turns number.

The known solutions have the following important drawbacks:

- transformers with rated power up to 10MVA and rated voltages under 110kV have usually off-load tap-changers;
- on-load tap-changers are made only for high voltage at different currents range;
- the nowadays tap-changers have a very laborious and in great details checking system;
- a big value for drive time, for instance, 50…60ms at fast tap-changers with resistances and up to 2 seconds, at tap-changers with reactance's;
- a momentary short-circuiting of turns winding involved within switching process;
- a special and very complex construction (diverter switches, selectors, preselectors, resistances and reactance's, special winding construction), which leads to high prices, big sizes and many operating difficulties;
- there are dynamic mechanical switches which have an easily degradation because of high electrical currents under switching process;
- the switching process has many successive steps at prescribed order;
- the possibility to break off phases under switching process;
- there are a lot of difficulties to make an automatic switching process;
- small drive number of on-load tap-changers, which leads to many overhauling.

Important companies, such as Maschinenfabrik Reinhausen (MR), makes performance on-load tap-changers but only within high voltage range and big value currents.

Taking into account that the most industrial and domestic consumers need low voltage power supply, it is necessary an important study concerning low voltage on-load tap-changers and new optimal solution in concordance with consumer requests.

2. On-load modular tap-changers

Further on it presents a new type of on-load tap-changers for power transformers. It uses a distinct module, which modifies secondary voltage both at increasing and decreasing values.

The presentation is made for star connection of power transformer but adjustment principle is the same and not depending on connection type and if transformer is single-phase or three-phase.

The secondary winding of power transformer for each phase, AX, BY, CZ, fig.1, is connected through detachable contacts Cd, at a distinct control module. Its main component is the adjustment transformer Tra, with the secondary S, and primaries P_1, $P_2...P_n$, with different turns number N_1, $N_2...N_n$.

In the case when secondary voltage U_2 of power transformer remains within admissible limits, then secondary S, of adjustment transformer Tra, is short-circuited by the switch K_s, fig.1. Thus, the output voltage U_2', will be equal with voltage U_2. Also, in this case, the secondary S, of adjustment transformer Tra, could not be short-circuited and it remains out of load. So, there is a negligible voltage drop across secondary winding and output voltage will be $U_2' \cong U_2$.

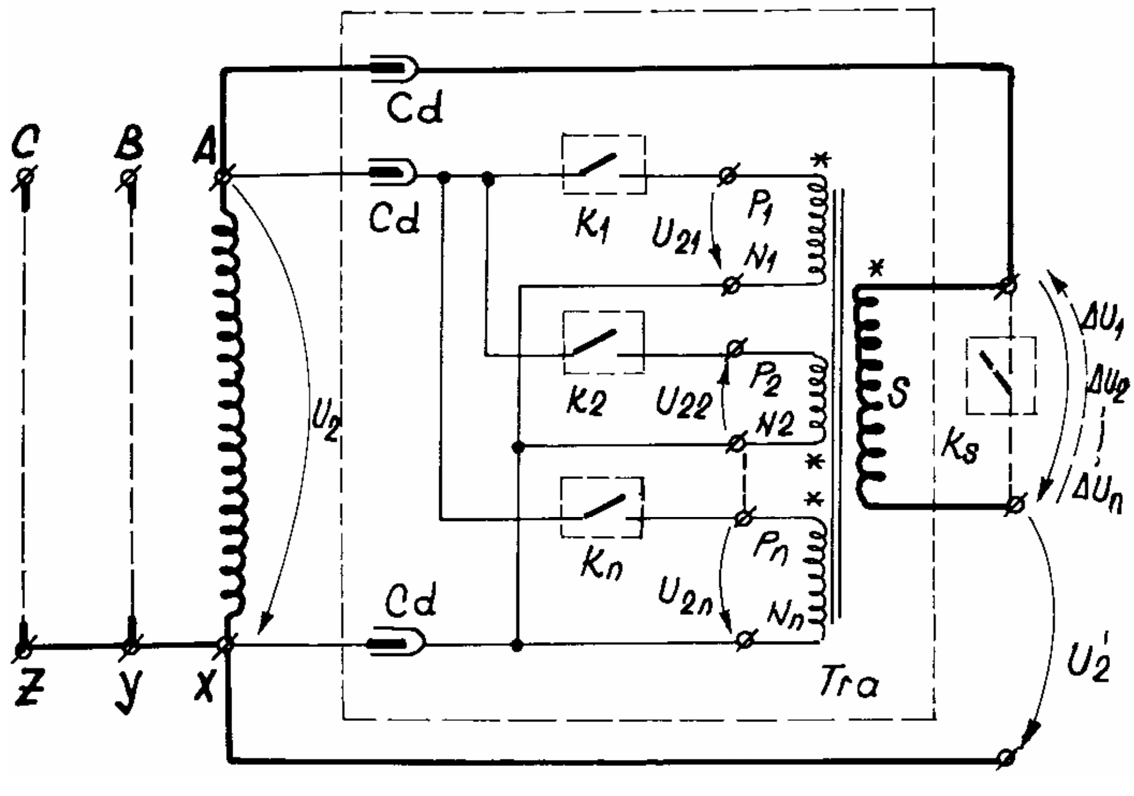

Fig.1

If secondary voltage U_2 of power transformer exceeds the admissible limits then one or more primaries P_1, $P_2...P_n$ of adjustment transformer Tra, are connected across secondary of power transformer through switches K_1, $K_2...K_n$. Thus, there will be across the secondary S, an additional voltage ΔU_1, $\Delta U_2...\Delta U_n$, which can be added or subtracted at initial voltage U_2, depending on polarity of primary windings P_1, $P_2...P_n$, and finally leading to a voltage U_2' with values within admissible limits for consumers.

So, for instance, at voltage increasing U_2 of secondary power transformer, over admissible values, it will turn-on the switch K_1 and will be voltage U_{21} across primary winding P_1 with turns number N_1. This voltage will induce into secondary S of adjustment transformer Tra, a voltage ΔU_1 (turn-off state for switch K_S), which subtracts from initial voltage U_2, resulting the value $U_2^{'}$ which has to be within admissible limits.

In the case of voltage decreasing U_2 of secondary power transformer under admissible values, it will turn-on the switch K_2, for instance, and so it will be voltage U_{22} across primary winding P_2 with turns number N_2. The variable magnetic flux through primary winding P_2, which made the voltage U_{22}, is by opposite side to magnetic flux, which crossed the winding P_1 from previous case, because of different polarization of primary P_2 comparatively with primary winding P_1, fig.1. Thus, the voltage U_{22} will induce into secondary S, a voltage ΔU_2, which will add at initial voltage U_2, given an admissible value $U_2^{'}$.

For other tap values, it can use „n" primary windings P_n with different turns number N_n, connected through switches K_n. Thus, the voltage U_{2n} across primary winding P_n will induce into secondary S of adjustment transformer Tra, a new voltage ΔU_n, which can be added or subtracted at initial voltage U_2, depending on polarity of primary winding P_n with the aim to get an admissible voltage value $U_2^{'}$.

The switches K_1, K_2...K_n, which are used to connect the primaries P_1, P_2...P_n, are made with controlled semiconductor devices, such as anti parallel thyristors, triac or other controlled semiconductor device with the aim to achieve a minimum drive time and to improve the reliability of on-load tap-changer. Also, when it uses a small number of taps, it can use vacuum switches because of their high reliability.

Also, there is the possibility to make the adjustment transformer Tra, from control module, with only one single primary winding P, but with tap steps with different turns number N_1, N_2...N_n, fig.2. The connection of tap steps at secondary of power transformer is made through solid-state switches K_1, K_2...K_n, depending on necessary taps.

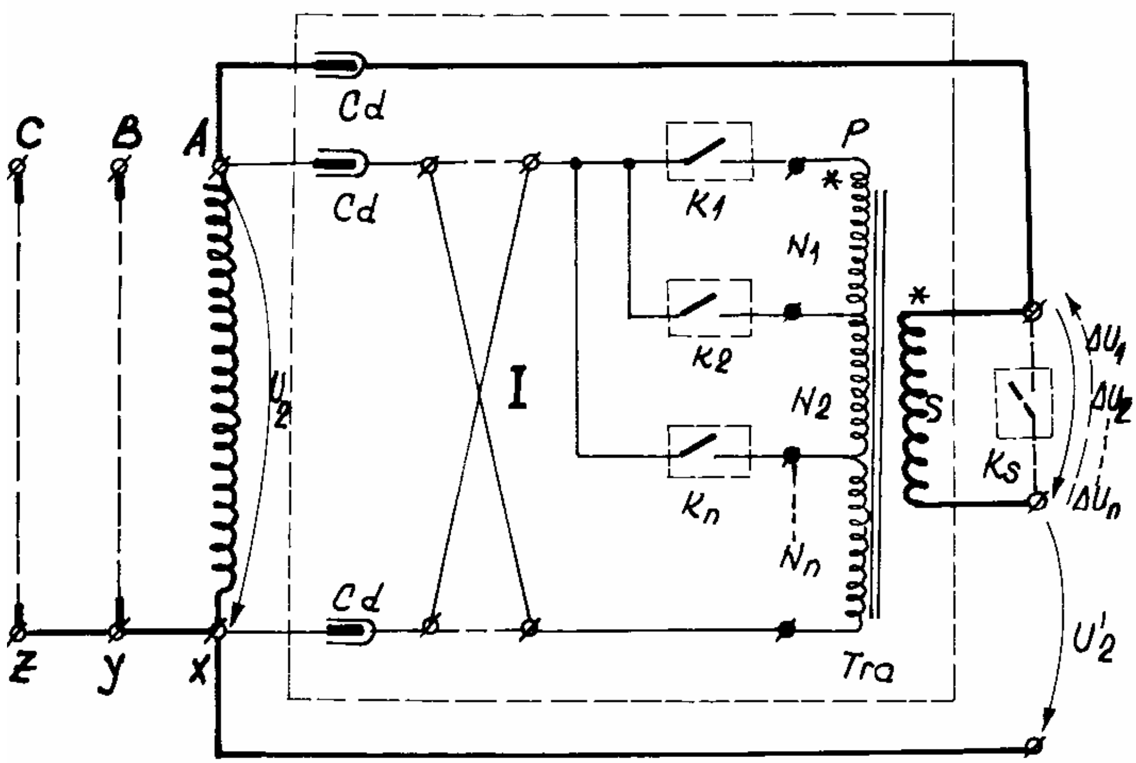

Fig.2

To have the adjustment possibility both at increasing and decreasing values, it is necessary to use a changeover switch I, fig.2, to invert the tap steps winding polarization. Thus, the induced voltages ΔU_1, $\Delta U_2 ... \Delta U_n$, into secondary S of adjustment transformer Tra, will be able to add or subtract from initial voltage U_2, resulting the voltage U_2', an admissible value.

A variant as regards the power electronic circuit to make on-load switching process is shown in fig.3. Unlike previous electric circuit, it can observe a double number of solid-state switches but there is no the changeover switch I. Thus, to each tap step of primary winding P of adjustment transformer Tra, with different turns number N_1, $N_2 ... N_n$, there is the possibility to change their polarity using an adequate control circuit upon solid state switches K_1, $K_2 ... K_n$. For instance, a change from $U_2 - \Delta U_1$ to $U_2 + \Delta U_1$ value, where ΔU_1 voltage means the induced voltage into secondary S, because of tap step with turns number N_1, means the switches K_1 and K_5 to turn-off and the switches K_2 and K_4 to turn-on. In the same way it can use any other tap step with turns number N_n of primary winding P of adjustment transformer Tra.

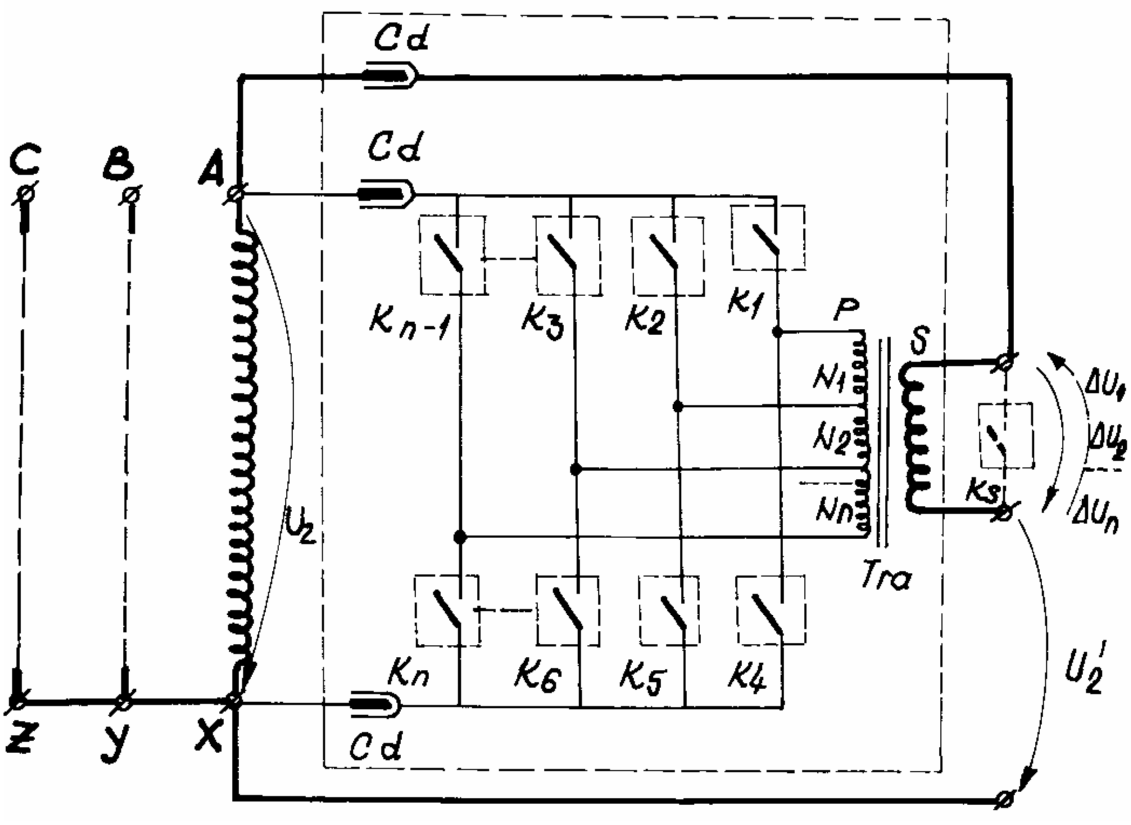

Fig.3

In all shown variants it requires an adequate control of solid state switches or vacuum switches to avoid any short-circuited tap steps or primary windings of adjustment transformer Tra, and to detect the optimal tap change for a given situation.

Also, the new type of on-load tap-changer allow to be mounted not only at power transformer stations but also closer to far-away and isolated consumers. Fig.4 shows a possible practical situation where should be used the control module MR, which can be mounted closer to power transformer TF, but also closer to consumers C_1, $C_2 ... C_n$, using control modules MR_1, $MR_2 ... MR_n$ which keep the voltage level among admissible values.

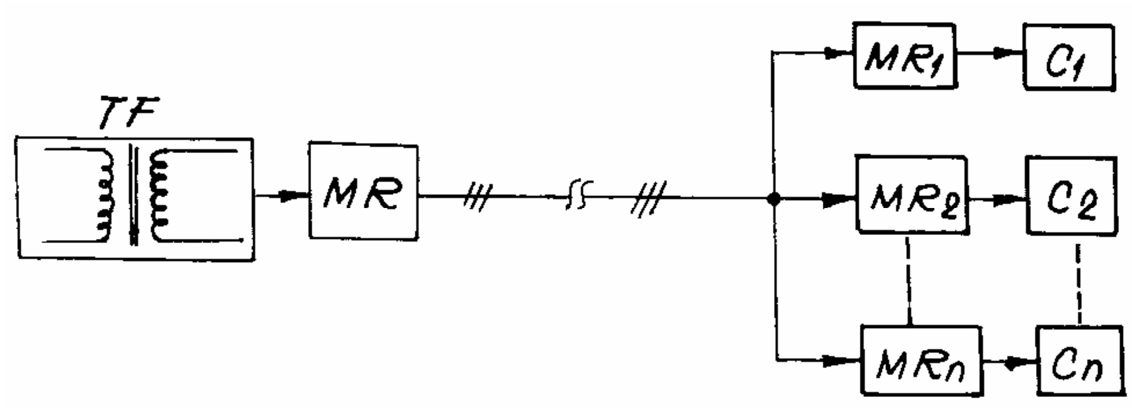

Fig.4

3. Conclusions

After all this study that was done as regards new types of on-load tap-changer for power transformers it highlights the following conclusions:

- the new type of tap-changer doesn't make momentary short-circuiting of turns winding involved within switching process and it is not necessary to use limiting reactance's;
- the possibility to keep automatically the voltage level among admissible limits independent on each phase;
- the switches used for tap-changer control have an improved reliability and it allow to use simple and efficient control circuits;
- there is not any possibility to break the phases of transformer secondary;
- simple construction and actual it is not necessary maintenance;
- more safety operating conditions;
- the possibility to replace only control module;
- it can use also at nowadays tap-transformers;
- the possibility to use the control module both at power transformer stations but also closer to far-away and isolated consumers.

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